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Review Article

A Comprehensive Review on Nephroprotective Activity of the Potential of Indian Traditional Medicinal Plants

Mudit Kumar[1, 2], Pushpendra Kumar[2], Mona Piplani[1, *]

[1]Maharaja Agrasen School of Pharmacy, Maharaja Agrasen University, Baddi Himanchal Pradesh, India
[2]Faculty of Pharmacy, Uttar Pradesh University of Medical Science Saifai, Uttar Pradesh, India

Abstract

Because they control waste elimination, electrolyte composition, and fluid balance, kidneys are essential for preserving homeostasis. Acute and chronic kidney illnesses are largely caused by exposure to nephrotoxic substances, including medicines, environmental pollutants, and metabolic abnormalities. With a growing reliance on dialysis and a scarcity of kidney transplants, the prevalence of chronic kidney disease (CKD) is rapidly increasing both globally and in India. Despite their effectiveness, conventional treatments can have negative side effects and are expensive. Because of their long history of traditional use, affordability, and safety, herbal and plant-based medicines are gaining popularity. This review thoroughly identifies medicinal plants that have been shown to have nephroprotective potential against kidney damage caused by drugs and toxins. Antioxidant, anti-inflammatory, and free radical scavenging mechanisms are the main ways that plants like Allium sativum, Aloe vera, Azadirachta indica, Curcuma longa, Ginkgo biloba, Withania somnifera, and several others have nephroprotective benefits. Flavonoids, alkaloids, saponins, polyphenols, terpenoids, and glycosides are among the phytoconstituents that are accountable. The function of these medicinal herbs in maintaining renal structure and function is firmly supported by experimental and preclinical data. This study highlights the therapeutic potential of nephroprotective plants and encourages more research into them in order to create safer and more potent renal protective medicines.

Keywords

Herbal Therapy, Antioxidants, Chronic Renal Disease, Medicinal Herbs, Nephrotoxicity, Nephroprotection Protection of the Kidneys, Phytochemicals

1. Introduction

All humans and vertebrates, the kidneys are an essential organ. Homeostasis maintenance is the kidney's primary function. The kidneys are negatively impacted by a number of harmful substances found in food and water. Since ancient times, plants and substances produced from them have been used extensively to treat and cure illness. Nearly 25% of pharmaceutical medications used to treat renal issues are still derived from plants [1]. Numerous medicinal substances, such as aminoglycoside antibiotics, NSAIDs, chemotherapy, and antitubercular medications, can negatively impact the kidneys and cause nephritic syndrome, acute renal failure, and chronic interstitial nephritis [2]. In India, there are 7852 cases of chronic renal disease for every million people [3]. In 2013, the global prevalence of renal failure was predicted to be between 8 and 16% [4]. CKD was the

*Correspondence: Mona Piplani (directorpharmacy@mau.edu.in)

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12th most common cause of mortality globally in 2017, accounting for 1.2 million deaths. Furthermore, poor kidney function may be responsible for 1.4 million deaths from cardiovascular disease, or 7.6% of all deaths. While age-standardized CKD mortality stayed constant between 1990 and 2017, global all-age CKD mortality rose by 41.5% [5]. The number of people receiving dialysis in India is increasing at a rate of 10-20% per year [6]. Kidney shortage is a worldwide issue, with Asia seeing the worst of it [7]. The most prevalent kidney issue is nephrotoxicity, which happens when the body is exposed to a toxin or medicine. Reduced urine concentrating capacity, tubular proteinuria and decreased ammonium excretion, a decrease in glomerular filteration rate, creatinine clearance and an increase in serum blood urea nitrogen (BUN), and a change in the morphology of kidney tissue are all functional manifestations of nephrotoxicity [8]. The World Health Organization reports that between 75 and 80 percent of people worldwide still primarily rely on herbal therapies due to their safety and lack of adverse effects [9]. For generations, men have utilized the ethanolic plant extract to boost their energy, vitality, and physical and sexual performance [10]. Alkaloids, steroidal saponins, flavonoids, and flavonol glycosides are only a few of the chemical components found in the many portions of the plant that are significant for medicine. The Chinese and Indian medical systems also employ the native medicinal plant to treat a variety of reproductive disorders [11]. The medicinal plants with nephroprotective properties will be highlighted in this review.

2. Plants That Protect the Kidneys

2.1. Allium Sativum L

One of the most significant and ancient herbs, garlic (family: Amaryllidaceae) is an aromatic herbaceous annual spice that has been used in traditional medicine since ancient times [12, 13]. It is regarded as the second most widely used Allium species, after onions (Allium cepa L.), and is used to treat a number of common ailments, including the common cold, the flu, snake bites, and high blood pressure [14]. A popular meal around the world, garlic has long been known for its therapeutic benefits [15]. Many biological properties, including renoprotective, antidiabetic, anticarcinogenic, antiartherosclerotic, antioxidant and immunological modulation, antibacterial, antihypertensive, and other biological actions, have been identified for garlic and its constituents [15-18].

2.2. Aloe Vera

Administration of A. vera at different doses (200-600 mg/kg) to albino rabbits decreased diclofenac sodium and silymarin induced nephrotoxicity. At various graded doses, the extract of A. vera showed notable improvements in serum creatinine and BUN levels. These findings demonstrated that A. vera is a useful nephroprotective agent against drug-induced nephrotoxicity and can restore the effects of oxidative stress [19].

The ability of an ethanolic extract of Annona reticulata's aerial parts to protect the kidneys from gentamicin and cisplatin-induced toxicity was assessed. According to histopathological findings, plant extract at a 500 mg/kg curative dose protects against gentamicin-induced nephrotoxicity. Phytochemicals investigation reported the major chemical constituents of the ethanolic extract to be acetogenins, alkaloids, flavonoids, proteins, carbohydrate etc. Therefore, it is known that acetogenins and alkaloids together have cytotoxic and nephroprotective properties [20].

2.3. Azadirachta Indica

One of the most promising medicinal plants is Azadirachta indica, also known as neem (family Meliaceae). It has a variety of biological activities and is well-known for its insecticidal qualities. The protective effects of need have been the subject of numerous studies [21-23]. The aqueous extract of neem leaves was found to be well tolerated, and when administered for 28 days at a dose of up to 2.5 g/kg (single administration) or 1 gm/kg, no mortality or histological abnormalities in the kidney, liver, testis, or adrenals were observed [24]. In a study by akinola et al. [25] they found that leaf extract of A. indica ameliorates hyperglycemic and diabetic nephropathy.

2.4. Brahmi

The common name for Bacopa monnieri L. (family: Scrophulariaceae). It is a medicinal herb, found throughout the Indian subcontinent in wet and marshy places. It has been utilized for centuries as a diuretic, brain tonic, memory enhancer, and anti-anxiety in the Ayurvedic medical system [26].

2.5. Celastrus Paniculatus

Sometimes called Maalakaangni, Vaaluluvai, or Jyotishmati, is a member of the Celastraceae family. Theseeds' protective effect against lead acetate-induced nephrotoxicity was attributed to their notable antioxidant properties [27].

2.6. Centella Asiatica

Sometimes known as CeA, is a medicinal herb that grows in tropical and subtropical regions, particularly in humid environments. It is a member of the Apiaceae family. Although the use of Centella asiatica in the treatment of kidney fibrosis is still unclear, particularly in relation to inflammation and mesenchymal transition, the impact of CeA on kidney fibrosis treatment is evident.

2.7. Coriandrum Sativum

It is a significant medicinal herb with hepatoprotective, diuretic, carminative, digestive, and anthelminthic properties.

Jaundice is another condition that the plant is used to cure. The ethyl acetate extract of Coriandrum sativum ameliorates the nephrotoxicity induced by gentamicin in a murine model [28]. The most significant components are flavonoids and polyphenols, which are a source of phytochemical nephroprotective potential.

2.8. Curcuma Longa

This perennial herb, which belongs to the Zingiberaceae (ginger) family, can reach a height of three to five feet. As a member of the ginger family, curcumin is the main curcuminoid found in the well-known Indian spice turmeric. Turmeric's yellow hue is caused by curcuminoids, which are polyphenols. Additionally, curcumin has nephroprotective properties [29].

2.9. Foeniculum Vulgare

In albino rabbits with gentamicin-induced nephrotoxicity, the nephroprotective effects of varying oral dosages of an aqueous extract of Foeniculum vulgare seeds (250 mg/kg), Solanum nigrum fruit (500 mg/kg), and their combination were investigated. For twenty-one days, all of the treatments were continued. High doses of both plants showed enhanced antioxidant and nephroprotective properties [30]. In experimental PCOS female rats, the renoprotective efficacy of F. vulgare aqueous extract (150 mg/kg low) was investigated.

2.10. Ginkgo Biloba

With thousands of years of clinical usage, ginkgo biloba is one of the most popular phytotherapeutic medicines worldwide. It is a traditional Chinese herbal remedy. Numerous animal studies have verified the curative and preventative benefits of G. biloba on diabetic nephropathy [31]. In diabetic nephropathy rats, G. biloba can improve the alteration of renal ultrastructure and reverse the rise in fasting blood glucose, 24-hour urine protein, blood urea nitrogen, and creatinine.

In rats with acute renal failure brought on by gentamicin, Glycyrrhiza glabra polyuria was linked to downregulation of renal aquaporin 2 in the cortex and inner and outer renal medulla. When glycyrrhizin (200 mg/kg/day) was administered, aquaporin 2 expression was restored along with alterations in urine production. Following the injection of glycyrrhizin, the alterations in renal functional parameters that accompanied acute renal failure were also largely recovered. By correcting the pathological alterations and lowering blood urea nitrogen and creatinine levels, glycyrrhizic acid significantly lessened acute kidney damage brought on by sepsis [32].

2.11. Jwarish Zarooni Sada

It is a well-known polyherbal remedy. According to Unani literature, this standardized pharmacopoeial formulation is diuretic, tonic for the kidneys and nephroprotective, and helpful for disorders including burning micturation, nephritis, and nephritic syndrome [33]. Its nephroprotective properties against gentamicin-induced nephrotoxicity were also studied.

2.12. Mentha Piperita L

Also referred to as peppermint, spearmint, or mint, is a member of the Lamiaceae family. The plant is used extensively as an anthelminthic, carminative, anti-spasmodic, and anti-motion sickness. One of the potential mechanisms proposed for the nephrotoxicity of the aminoglycoside gentamicin is damage brought on by the production of free radicals. By scavenging free radicals, M. piperita prevents kidney damage brought on by gentamicin [34].

2.13. Musa Sapientum

It has been reported that a methanolic extract of the bract, flower, trachea, and tracheal fluid of Musa sapientum has nephroprotective properties against gentamicin-induced nephrotoxicity in rats. Bract (100 and 250 mg/kg, body weight) and flowering stalk/trachea (250 and 500 mg/kg, body weight) methanolic extracts considerably inhibited the biochemical and histological alterations brought on by gentamicin poisoning [35].

2.14. Ocimum Sanctum

also referred to as holy basil, is a fragrant member of the Lamiaceae family. Ocimum sanctum leaves are made up of about 71% eugenol, ascorbic acid, vitamin A, phenolics, flavonoids, riboflavin, and minerals. They also contain 0.7% volatile oil [36]. The most common phenolic ingredient in the O. sanctum extracts was discovered to be eugenol, which may be a source of antioxidants with the ability to scavenge free radicals [37]. The liver and kidney were shielded against lead acetate exposure by O. sanctum leaf extract.

2.15. Picrorhiza Kurroa

Northwest India is the home of the little perennial herb Picrorhiza kurroa... It is a key herb in the old Ayurvedic medical system and has been used to cure scorpion sting, bilious fever, and bronchial and liver issues. Picrorhiza kurroa's active principal is Kutkin. Picrorhiza kurroa's nephroprotective activity is attributed to its active ingredients, kutkoside and picroside [38].

2.16. Pomegranates

Pomegranates (Punica granatum) are native to the Himalayan region of north India and Iran. They are members of the Punicaceae family. It is regarded as "a pharmacy unto itself" in Ayurveda [39]. The oldest ree with numerous health benefits is this one. Due to its antioxidant activity, which is as-

cribed to its high polyphenolic content and the presence of ellagic acid [41], pomegranates have been used in traditional literature to cure a variety of renal illnesses [40].

2.17. Tamarindus Indica

At 10 mg/kg body weight, the methanolic extracts of the fruit pulp, stem bark, fruit bark, and seeds had the best nephroprotective ability against CCl^4-induced nephrotoxicity in albino rats. The phytoconstituent groups found in several T. indica sections may be responsible for their organ-protective and medicinal properties [42].

2.18. Trichosanthes Dioica Roxb

Trichosanthes dioica is a significant medicinal plant. In various regions of India, it goes by the names parwal, parmal, patol, and potala. It has laxative, cardiotonic, antipyretic, and diuretic properties. Vitamin A, vitamin C, tannins, and saponins are among the several chemical components found in T. dioica [43]. Treatment with Trichosanthes dioica leaf extract (TLE) effectively stopped gentamicin-induced reductions in glutathione, catalase, and superoxide dismutase (SOD) activity levels. Numerous experimental models have demonstrated a connection between oxidative stress and nephrotoxicity [44].

2.19. Ashwagandha, or Withania Somnifera

It is a significant ancient plant whose roots have been used in Ayurvedic and Unani medicine. It is sometimes referred to as Indian winter cherry. Leprosy, arthritis, and rheumatism are just a few of the conditions for which it has been utilized. The two primary withanolides in this plant, withaferin A and withanolide D, have been linked to a large portion of its pharmacological activity [45]. Aswagandha is widely grown throughout India and has long been recognized for its antioxidant properties. It can be used as a nephroprotective medication to prevent nephrotoxicity caused by gentamicin [46].

Table 1. *Plants with Nephroprotective effects.*

S. No.	Plant Name (Family)	Part used	Vernacular name	Major Chemical constituents	References
1.	Allium sativum (Amaryllidaceae)	Bulb	Garlic	Allinase, allin, allicin, ajoene, S-allylcysteine	Michal Majawaski. Rocz Panstw Zakl Hig. 2014
2.	Aloe vera (Xanthorrhoeaceae)	Pulp of plant	Aloe	Aloin	A feily et al. G Ital Dermatol Venereol. 2009
3.	Annona reticulata (Annonaceae)	Leaves	Custard apple	Phenol, steroid, tannin, annonaretin A.	Prasad G. Jamkhande and Amruta S. Wattamwar.
4.	Azadirachta indica (Meliaceae)	Stem, bark, leaves	Neem	Aadirachtin, nimbolide	R Subapriya et al Curr Med Chen Anticancer Agents. 2005 mar
5.	Bacopa monnieri (Scrophulariaceae)	Leaves	Brahmi	Brahmine, bacoside A, bacoside B, essential oil	Venkatakrishnan Kamesh et al. Pharmbiol. 2014
6.	Celastrus paniculatus wild (Celastraceae)	Seed	Jyotishmati	Cinnamic acid, flavonoid, terpenoid (amyrin, lupeol), sterol	Mohd. Aleem. J complement Inegr Med. 2021
7.	Centella asiatica (Apiaceae)	Herb	Gotukola, Indian Pennywort	Asiaticoside, asiatic acid, madecassic acid,	Chandrika, UG, et al 2015
8.	Coriandrum sativum L. (Umbelliferae)	Leaves, fruits	Dhaniya	Flavonid, glycoside, fixed oil, linalool, geraniol, α-pinene	Abhijeet Lkhera et al. Interdiscip Toxicol. 2015 jun
9.	Curcuma longa (Zingiberaceae)	Rhizome	Turmeric	Curcumin, terpenoid	Venkatesan et al. 2000
10.	Foeniculum vulgare (Apiaceae)	Seed, root	Fennel, Saunf	Inulin, coumarins, umbeliferone, esculetin, scopoletin	Barun Das et al. PloS One. 2022
11.	Ginkgo biloba (Ginkgoaceae)	Leaves	Maiden hair tree	Ginkgolides A, B, C	Bruce J Diamond et al. Psychiatr Clin North Am. 2013

S. No.	Plant Name (Family)	Part used	Vernacular name	Major Chemical constituents	References
12.	Glycyrrhiza glabra (Fabaceae)	Root	Licorice	Glycyrrhizin, glabridin, liquiritin	Iranian Journal of basic medical Sciences, 2022
13.	Jwarish Zarooni Sada (Cucurbitceae)	Leaves, seed like fruit	Ajwain	Thymol, linoleic acid, oleic acid, p-cymene, xylene, palmitic acid	Gurdip Singh et al. J Agric Food chem. 2004
14.	Mentha piperita (Lamiaceae)	Fresh and dried leaves	Spearmint, Peppermint, Gardenmint	Carvone, limonene, 1, 8 cineole	Ganesan Mahendran et al. J Ethanopharmacol, 1987
15.	Musa sapientum (Musaceae)	Rhizome, pulp of fruit	Banana	Vitamin B & C, fructose, starch	K Mukhopadhyaya et al. J Ethanopharmacol, 1987
16.	Ocimum sanctum (Lamiaceae)	Root, leaves	Tulsi	Eugenol, ether, methanol, carbacol	P Prakash et al. Indian J Physiol Pharmacol. 2005
17.	Picrorhiza kurroa (Plantaginaceae/ Scrofulariaceae)	Leaves	Kutki, Katuka	Kutkoside, picroside I	Praveen C Verma et al. Curr Pharm Biotechnol. 2009
18.	Punica granatum (Lythraceae)	Peel of fruit	Pomegranate	Ellagic acid, punicalin, punicalagin	Erfanesg Shaygannia et al. J Evid Based Complementary Altern med. 2016
19.	Tamarindus indica (Fabaceae)	Seed	Tamarind, Imli	Flavone, vitexin, C-glycosidesorirntin, lauric acid, stearic acid	Sushant S Sole et al. Pharm Biol. 2013
20.	Trichosanthes dioica (Cucurbitaceae)	Leaves	Parmal, Parwal	Vitamin A & C, tannins, saponins	Nitin Kumar et al. Pharmacogn Rev. 2012
21.	Withania somnifera (Solanaceae)	Leaves	Ashwagandha	Alkaloids, steroids, glycosides, reducing sugar	Thangavel Jeyanthi et al. Ren fail. 2009

3. Discussion

The plant crude extract mentioned above was subjected to phytochemical analysis. It demonstrated the existence of several significant phytochemical types. These phytoconstituents, which include alkaloids, flavonoids, glycosides, and saponins, exhibit encouraging anti-nephrotoxicity properties. In addition to the fact that herbal remedies are thought to be safe, many people in developing nations rely on them because contemporary medications are too expensive for them. The ability of each plant under discussion to scavenge free radicals was used to calculate its antioxidant activity. Following treatment of all the extracts for the in vivo investigation for the behavioral trial, the plant extract exhibits no abnormalities. As a result, research into plants as potential medical sources has gained importance.

4. Conclusion

One of the most frequent and difficult side effects of long-term medication use and exposure to environmental pollutants is still nephrotoxicity. The rising incidence of CKD worldwide emphasizes the critical need for efficient, secure, and affordable treatment approaches. Because of their diverse modes of action, which include cytoprotective, anti-inflammatory, and antioxidant activities, and their rich phytochemical profiles, medicinal plants have become important sources of nephroprotective drugs. The traditional usage of the plants covered in this article for renal problems is supported by their notable protective effects against renal injury in a variety of experimental models. Although preclinical results are encouraging, standardization of herbal formulations and well-planned clinical trials are necessary to confirm their effectiveness and safety in humans. To sum up, medicinal plants present a promising alternative and supplementary strategy for the management and prevention of kidney disorders and nephrotoxicity, opening the door for future drug development and integrated nephrotherapeutic approaches.

Abbreviations

CKD	Chronic Kidney Disease
PCOS	Polycystic Ovarian Syndrome
TLE	Trichosanthes Dioica Leave Extract
SOD	Superoxide Dismutase
BUN	Blood Urea Nitrogen

Author Contributions

Mudit Kumar: Conceptualization, Resources
Pushpendra Kumar: Methodology, Visualization
Mona Piplani: Data curation, Supervision

Conflicts of Interest

We declare that we have no conflicts of interest.

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